

18 MAY. 1914
ENTOM.

DECEMBER 17, 1898

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION.

W. A. WITHERS, A. M., ACTING DIRECTOR.

THE
ADULTERATION OF COFFEE
AND TEA

OFFERED FOR SALE IN NORTH CAROLINA.

W. A. WITHERS AND G. S. FRAPS.



RALEIGH N. C.

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NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

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THE ADULTERATION OF COFFEE AND TEA.

W. A. WITHERS, A. M., CHEMIST,

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The General Assembly of North Carolina enacted, in 1895, a law which made the adulteration or misbranding of articles of food a misdemeanor, but no one was charged with the duty of executing the law. The present bulletin is one of a series of investigations, undertaken by the Station, to ascertain the extent to which adulteration is practiced on some of the most common articles of food sold in the State. It is necessary to give first a brief account of the methods which have been employed for the adulteration of coffee and tea, and the manner in which the adulterations are detected, before going on to the results obtained in the examination of the samples.

ADULTERATION DEFINED.

A clear and unambiguous definition of adulteration is needed before beginning the study of the subject. One must know exactly what constitutes an adulteration before he can say "this article is adulterated." An excellent definition is found in the act of the General Assembly alluded to above:

The term "food," as used herein, shall include all articles used for food or drink by man, whether simple, mixed, or compound. The term "misbranded," as herein used, shall include all articles of food, or articles which enter into the composition of food, the package or label of which shall bear any statement purporting to name ingredients or substances as being contained, or not being contained, in such article, which statement shall be false in any particular.

An article shall be deemed to be adulterated in the case of food or drink:

- (1) If any substance or substances has, or have been, mixed or packed with it so as to reduce, or lower, or injuriously affect its quality or strength, (so that such product, when offered for sale, shall be calculated and shall tend to deceive the purchaser.)
- (2) If any inferior substance or substances has, or have been substituted wholly, or in part, for the article.
- (3) If any valuable constituent has been wholly, or in part, abstracted.

(4) If it be an imitation of, or sold under, the specific name, brand or trade mark of another article.

(5) If it be mixed, colored, powdered or stained, in a manner whereby damage is concealed.

(6) If it contain any added poisonous ingredient, or any ingredient which may render such article injurious to the health of the person consuming it.

(7) If it consists of the whole, or any part, of a discarded, filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, whether manufactured or not, or if it is the product of a diseased animal, which has died otherwise than by slaughter.

Provided, That an article of food which does not contain any added poisonous ingredient shall not be deemed adulterated or misbranded in the following cases :

(1) In the case of mixtures or compounds, which may be now, or from time to time hereafter, known as articles of food under their own distinctive names, and not included in definition fourth of this section.

(2) In the case of articles labeled, branded, or tagged, so as to plainly indicate that they are mixtures, compounds, combinations or blends.

(3) When any matter or ingredient has been added to the food because the same is required for the production or preparation thereof, as an article of commerce in a state fitter for carriage or consumption, and not fraudulently increase the bulk, weight or measure of the food, or conceal the inferior quality thereof. *Provided*, that the same shall be labeled, branded, or tagged, so as to show them to be compounds; *and provided, further*, that nothing in this act shall be construed as requiring or compelling manufacturers of articles of food to disclose their trade formulas.

(4) When the food is unavoidably mixed with some extraneous matter in the process of collection or preparation.

The fifth definition of adulteration given, is defective. In the New York State Law, it reads: If it be colored or coated or polished, whereby damage is concealed, or it is made to appear better than it really is, or of greater value.

ACKNOWLEDGMENT.

Free use was made of the following works in the preparation of this bulletin: Hassall's, Blyth's and Battershall's works on food adulteration; James' Bell's Chemistry of Foods; and Bulletin No. 13, U. S. Department of Agriculture, Division of Chemistry, on Foods and Food Adulteration. The last named publication, prepared under the direction of Dr. H. W. Wiley, deserves special mention and acknowledgment.

COFFEE.

The coffee tree is a shrub-like plant, cultivated in various tropical countries. The tree bears a fruit resembling a small cherry, with two seeds or coffee grains embedded in the pulp. The fruit is dried, and the seeds removed from the outer covering. Coffee, as imported, contains a certain amount of broken grains, immature and light grains, portions of the outer covering, sticks and other foreign matter. These are removed by screens—sifted, as it were—and by a blast of air, which carries away the lighter materials. The amount of such material left in the coffee would depend on the thoroughness of the purification.

Coffee moderately excites the circulatory system and stimulates the digestive function. It gives rise to increased vigor of imagination and intellect, without any subsequent confusion or stupor, and another of its effects is a disposition to wakefulness. But taken in large quantities, it leaves, after its first effects, a degree of nervous derangement or depression, equivalent to the previous excitement. Its habitual immoderate employment is well known very greatly to injure the tone of the stomach, and frequently to occasion troublesome nervous and dyspeptic affections.*

The properties of coffee are mainly due to three substances, an essential oil, cafeeo-tannic acid, and caffeine. Caffeine has a decided action on the animal organism, and coffee probably owes much of its value to its presence; the similar effects of coffee and tea have their source in the possession of caffeine by tea also. The percentage of caffeine in coffee varies from about 0.6 % to .2.2 %. It has about 11 % of cafeeo tannic acid, and the quantity of essential oil is very small. Raw or green coffee contains about 11 % moisture, coffee roasted, 1.2 % moisture.

THE ADULTERATION OF COFFEE

According to the definition of adulteration already given, coffee may be considered as adulterated; if foreign matter of any kind has been added to reduce the strength or affect the quality; if cheaper substances have been substituted in part, or wholly, for the coffee; if the coffee has been colored to imitate better grades or to conceal damage.

It is purposed to give here a short account of the methods which have been used to adulterate coffee, and the manner in which these adulterations may be detected. Ground coffee is tampered with much more than whole coffee, as the condition of the mixture makes such operations less easily detected than with whole coffee.

*U. S. Dispensatory.

Facing.—The coloring of coffee, to imitate better grades, or otherwise improve the commercial value, is called facing. Some of the pigments used are Prussian blue, indigo, lead chromate, clay, azo colors, and charcoal. The raw berry is moistened with water containing a little gum and agitated with the coloring mixture. The coloring matter used forms only a very small percentage of the coffee; and while the pigments might be harmful if consumed in appreciable quantity, one would have to drink a large amount of coffee to take even the smallest medicinal dose. There is no evidence that the coloring matter is injurious to the health, but injurious or not, its presence is an adulteration.

Detection.—To detect facing, the coffee is shaken with water, and the sediment examined microscopically or chemically. With the microscope, greenish blue particles show the presence of indigo; brilliant blue particles, Prussian blue. Azo colors are dissolved by soaking the coffee in alcohol; the aqueous solution obtained from this will give the characteristic reactions. Lead chromate is detected in the ash by the usual qualitative tests for lead and chromium. Facing is usually confined to green coffees.

Glazing.—Coffees are often roasted with the addition of sugar or syrup. This is called glazing. Some coffee roasters claim that it is necessary to glaze the coffee to prevent the loss of its aroma, or the absorption of qualities that are injurious to it. Experiments have shown that coffee roasted with sugar weighs from four to twelve per cent. more than the same coffee roasted without sugar. This gain in weight is a decided advantage to the roaster, and as decided a disadvantage to the consumer. The increase in weight is due partly to the roasted sugar and partly to the water, which is retained to a greater extent by the glazed than by the unglazed berry. Excessive glazing gives the berry a glossy black appearance, and the dark brown substance formed by roasting sugar colors the coffee infusion and makes it appear stronger than it really is. Moderate glazing need not be considered an adulteration if the fact is stated on the label; excessive glazing must be considered so under any circumstances.

To detect glazing, 20 grams of the whole beans are violently shaken with 500 cc distilled water for five minutes, diluted to 1,000 cc, 50 cc of the filtered liquid evaporated, dried, weighed, ignited and the ash deducted. Pure roasted coffee shows from 0.44 to 0.72 per cent. soluble organic matter, while coffee roasted with sugar gives from 1.81 to 8.18 per cent., according to Stutzer and Reitnair. With this work as a basis, it would be fair to assume that coffee, giving an organic extract greater than 1 % has been glazed, while if more than 2 % it is excessively glazed. Further investigation may change these limits; they allow a liberal latitude for variation in coffees, and are based upon experimental work.

Coffee Screenings.—As already stated, coffee, as imported, contains immature and light grains, broken grains, and foreign matter, and these are usually removed as screenings. Coffee screenings largely consist of fragments of pure coffee beans, yet, if sold as coffee, or mixed with coffee, they must be considered as adulterants. One cannot demand that a cheap coffee be carefully purified. It is to be expected that coffee of this kind will contain a certain per cent. of broken grains and immature grains, and also a very small per cent. of the impurities which naturally accompany coffee. Exactly what limits should be set to this allowance, limits which, if exceeded, would condemn the coffee as adulterated, this bulletin cannot undertake to fix. Such limits could be formulated only on the basis of a careful examination of numerous coffees as they are imported, and a study of the process of screening or purification. It is very desirable for those who have to examine foods to possess standards of this kind. Such standards have been adopted for use in the examination of tea and of vinegar, and they are necessary for coffee also, as far as glazing and impurities incidental to the gathering of coffee. In the absence of a standard it may be asserted, in general terms, that the coffee should not contain a high percentage of broken or immature grains, or more than an insignificant quantity of incidental impurities, as sticks, stones, etc.

Detection. Broken coffee and immature coffee may be easily separated from the whole grain. With ground coffee, this is impossible. The presence of coffee screenings in ground coffee may be inferred, if any considerable amount of sand can be separated. In the case of a coarsely ground coffee sometimes the outer hull of the berry can be picked out when the coffee has been adulterated with coffee screenings. The hull has a peculiar coiled, shell-like shape where it joins the stem. Sand and stones can best be separated by pouring the coffee on water, and sorting the sediment.

Imitation Coffee.—Imitation coffees or coffee substitutes are manufactured on a large scale in America, Germany, and England. Of twenty-two imitation coffees collected by the U. S. Department of Agriculture in 1892, and examined in its laboratory, two were imitation raw coffee beans, eleven imitation roasted coffee beans, and ten were pellets and granule. They consisted chiefly of wheat flour, bran, and chicory, with occasionally some coffee. The use of imitation coffee, for the genuine article is clearly fraudulent.

Detection. The addition of imitation coffee to ground coffee really amounts to the addition of flour, bran, and chicory, and the method of detecting these substances will be indicated later. Roasted coffee will usually float on water or 40 per cent. alcohol, while imitation coffee sinks. Imitation beans may be detected in whole roasted coffee by the presence of a small particle of parchment-like structure in the cleft of that which sinks, or by the ap-

pearance of its structure. In green coffee, the imitation can be found only by a careful bean-by-bean examination, breaking each one. In either case the tests mentioned above for use with ground coffee may be applied.

Root Adulterants.—Roasted roots of the dandelion, turnip, chicory, etc., have been used as adulterants. The addition of chicory is a common practice. Chicory is the prepared root of the plant *Chicorium Intybus*, largely cultivated in Europe; the root is used as a substitute for coffee, or to adulterate it. Many coffee drinkers prefer a mixture of coffee and chicory to pure coffee, and such a mixture may be properly sold if its composition is stated on the package, or made known to the purchaser; otherwise the mixture must be condemned as adulterated.

Detection. If ground coffee be sprinkled on water, nearly the whole of it will float, coloring the liquid but slightly; chicory will separate and sink, imparting a brown color to the liquid. A microscopic examination of the particles which sink is necessary, when chicory reveals itself by the peculiar nature, of their structure. A heavily glazed coffee would color the water whether chicory were present or no. Other tests for chicory are known, but need not be mentioned in an article of this kind.

Seeds and Seed Products.—Canna seeds, cassia seeds, ground date stones, leguminous seed, such as peas and beans, and finally the cereals, as wheat, barley, and rye, have all been used, from time to time, as coffee adulterants. In this country, cereals and leguminous seeds are used; the occurrence of the others here is very rare. Like chicory, the cereals and leguminous seeds will sink in water, imparting a decided color. Moistened with water, they become softened, while coffee remains hard.

Detection. Coffee contains no starch, while the great majority of seeds, likely to be mixed with it, as beans, peas, acorns, cereals, all cereal products, imitation coffee—all contain a notable quantity. The absence of starch shows that none of these are present. Starch is easily detected chemically or microscopically. To detect it chemically in coffee, the powdered coffee is boiled with water, cooled perfectly, acidified with dilute sulphuric acid, and a strong solution of potassium permanganate added cautiously, until the coloring matter is nearly destroyed. The filtered liquid gives a blue coloration with a solution of iodine if starch is present. To detect starch microscopically, the finely powdered sample is mounted in Canada balsam and examined with polarized light. Starch shows a dark cross on a white field. If starch is found, the problem is next to determine the nature of the admixture, that is, whether it be peas or beans or wheat or something else. The origin of a starch can be detected by the microscope, as will be shown in the Bulletin on the Adulteration of Flour. Sufficient of the original structures will usually remain, to allow of their com-

plete microscopic identification, so one can tell if flour or bran, peas or pea-hulls, have been used.

EXAMINATION OF SAMPLES BOUGHT ON THE OPEN MARKET.

The object of this investigation, it may be repeated, was to ascertain the extent of adulteration of the coffee for sale in North Carolina, and the nature of the adulterants used. To attain this object, each sample should represent as great a number of pounds of coffee as possible; each should be of wide, rather than local application. Probably all cheap roasted coffees sold in North Carolina are placed on the market in small packages of unground grains, mostly containing a pound. The higher grades usually come in large packages. Most stores possess a coffee-mill, and if the customer desires ground coffee the whole bean is ground before his eyes. While this is, of course, no guarantee that the coffee is not mixed with some adulterant during the process of grinding, this investigation could not concern itself with such individual adulteration of merely local bearing. The samples must be representative of more than a single locality. Such samples are offered by the coffees which come on the market in sealed packages, and by samples of whole roasted coffee as it reaches the dealer. Accordingly, samples of this kind were collected by purchase from all grades of stores, and made the object of an examination.

DESCRIPTION OF SAMPLES.

Laboratory Number.	Brand.	Packer or Roaster.	Price per Pound	Where Purchased.
1043	Special	Bulk	25	Statesville.
1044	Number Twelve.	Not given	10	Statesville.
1045	Ariosa	Arbuckle Bros	13	Statesville.
1046	Levering's	E. Levering & Co.	12	Statesville.
1080		Bulk	15	Raleigh.
1081	Lion	Woolson Spice Co.	20	"
1082	Aden Mocha	Bulk	18	"
1083	Crescent	Smith Bros	20	"
1138	Red Seal, Number Nine, ...	Not given	10	"
1139	Hero. Coarse ground	Not given	10	"
1140	Princess	F. Middleton & Co.	13	"
1141	Red Seal, Number Ten	Same as 1138	10	"
1142	Crescent	Same as 1083	13	"
1143	Lown's Capital	W. G. Lown	13	"
1144	Mocha and Java Blend	Bulk	25	"
1154		Bulk	12½	Durham.
1155	Arica	Austin, Nichols & Co	12½	"
1156	Crown	Conley, Ach & Conley	25*	"
1157	Star	W. G. Lown	20†	"
1158	Monogram	Charleston Impt. and Expt. Co	35	Raleigh.
1190	Red Owl	" "	12½	Raleigh.
1202	Momaja	American Grocery Co	30	Henderson.

*Crown coffee was 25 cents with cup, saucer, and plate. †Star coffee was in milk can.

The coffees in the table not stated to be in bulk were in packages. Three of them were of unknown origin, and therefore suspicious, as a reliable dealer is always ready and willing to have his name advertised on the package. The name of No. 1044 varies with the locality; in Statesville it was called "Number Twelve," in Raleigh "M and S," and packages were also found in Raleigh which bore no name. This coffee is put up in yellow packages, and a name printed on to suit the retail dealer. No. 1140 (Princess) contained a teaspoon, as stated on the package; No. 1143 (Lown's Capital) contained a stick of candy, weighing $\frac{1}{2}$ oz., and the fact was not stated on the package. The selling of candy, teaspoons, etc., in a sealed package with coffee must needs be condemned as adulteration, unless the fact of such admixture is distinctly labeled on the package. Such sophistications are ingenious, as the purchaser does not always realize that he is buying the candy, etc., at the price of coffee, and is disposed to consider it as a gift.

Facing.—All the coffees were roasted; there was no reason to examine them for facing, which is confined almost exclusively, to green coffees.

Glazing.—A test was made for glazing, in the manner already described. The percentage of cold water extract found in that way is given in the following table:

1043 0.73	1082 1.09	1155 1.84
1044 2.36	1083 1.81	1156 1.35
1045 1.92	1140 1.39	1157 2.50
1046 1.19	1143 2.20	1158 0.99
1080 2.78	1144 0.82	1190 1.48
1081 1.46	1154 1.15	

On the basis of the limits already laid down, (see Glazing) we must consider coffees giving more than one per cent. organic extract to be glazed, that is, roasted with sugar or other glazing material, and if the coffee shows over two per cent. organic extract, it is to be considered as excessively glazed. All the above samples, except three (1043, 1144 and 1158), must be considered as glazed; four are excessively glazed:

1044, Number Twelve.....	Unknown origin.
1080	bulk.
1143, Lown's Capital.....	W. G. Lown.
1157, Star	W. G. Lown.

The extract was not determined in Red Seal, (1138, 1141) and Hero (1139), on account of their broken condition, but both were probably glazed, a fact recognized by even a casual examination. The method of examination for glazing could not fairly be applied to a broken coffee.

It should be recalled that the result of glazing is an increase in weight of the coffee, and that excessive glazing must always be considered as an adulteration. Moderate glazing is allowable if the fact is labeled on the package; this statement was made on Arica (1045) and Crown (1156), some of the coffees asserted absolutely that no glazing material whatever had been used in their preparation.

In the following statements only the coffees are included whose organic extracts are in the table.

Of 17 coffees, 14 were glazed—82%.

Of 17 coffees, 4 were excessively glazed—23.5%.

Of three coffees costing over twenty cents per pound, all were unglazed.

Of fourteen coffees costing less than twenty cents per pound, all were glazed.

It is curious that while some manufacturers assert that glazing is necessary to the preservation of the coffee, all the high-grade coffees were unglazed, and all the low grade glazed. If glazing is necessary to preserve the good qualities of a poor coffee, how much more necessary ought it to be to preserve the better qualities of a fine coffee.

Coffee Screenings.—The following table includes coffees whose content of broken coffee, or of immature and damaged coffee, is greater than ten per cent, and also those which contain foreign matter, such as sticks, stones, and the outer covering of the coffee berry:

Number.	Brand.	Immature and Damaged Coffee.	Broken Coffee.	Foreign Matter.
		Per cent.	Per cent.	Per cent.
1044	Number Twelve.....	25	28.5	
1046	Levering's.....			0.5
1083	Crescent.....	14	23.5	1.4
1138	Red Seal, Number Nine..	13	47.5	5.5
1139	Hero.....	Coarse ground		7.6
1140	Princess.....			0.2
1141	Red Seal, Number Ten..	10	42	7.1
1142	Crescent.....	Not determined....	12	0.3
1154			10	1.0
1155	Arica.....			1.0
1156	Crown.....		13	2.4
1190	Red Owl.....	11		0.6

The small amount of foreign matter in most of the above coffees was probably due to imperfection in the process of screening, not to any fraudulent admixture. The following coffees, however, must be considered as adulterated with coffee screenings:

1044, Number Twelve, unknown origin.

1138 } Red Seal, unknown origin.
1141 }

1139, Hero, unknown origin.

1083, Crescent, Smith Bros.

Crescent, 1142, was very different in character from Crescent 1083, and the former cannot be considered as adulterated. The foreign matter in Hero was largely composed of the outer hull of the coffee berry and sand. Although the sample was coarsely ground, 7.6 % of this material could be picked out of it, and there is good reason to presume this coffee is composed entirely of coarsely ground coffee screenings. The list above justifies the warning against goods of unknown origin. A dealer is glad to advertise himself on the label of articles of medium or even only good quality. When he refuses to place his name on a package of goods one can suspect something is wrong. Of three coffees examined of unknown origin, three were adulterated.

In 20 coffees, 4 were adulterated with coffee screenings—20 %.

Imitation Coffee.—Tests for imitation coffee were made in every sample examined; no imitation coffee was found. The present low price of coffee probably discourages the manufacture of imitation coffee. Cheap coffee is so cheap that it hardly pays to manufacture coffee to mix with it, and high-grade coffee can be more easily mixed with cheap coffee with less danger of detection. This may account for the absence of the imitation in all the samples examined.

Root adulterants, seeds and seed products, cannot be used to adulterate whole coffee very well. Their sphere of activity is the ground article. They enter into whole coffee in the form of imitation coffee.

SUMMARY.

In 20 coffees, four were adulterated with coffee screenings—20 per cent.

In 17 coffees, 14 were glazed—82 per cent.

In 17 coffees, 4 were excessively glazed—23.5 per cent.

In 20 coffees, 7 were adulterated—35 per cent.

All cheap coffees examined were glazed.

All coffees of unknown origin were adulterated.

No high priced coffees were found adulterated.

STATISTICS OF COFFEE ADULTERATION.

U. S. Department of Agriculture.

18 green coffees, none adulterated.

60 whole roasted coffees, 6 adulterated—10 per cent.

30 ground coffees, 27 adulterated—90 per cent.

In 50 % of the ground coffees, the purchaser obtained only half, or less than half, the coffee he paid for.

Connecticut (1897).

26 whole-roasted coffees, 2 adulterated 7.7 %.

45 ground coffees, 39 adulterated 87 %.

Pennsylvania.

120 coffees examined, 16 adulterated 13.3 %.

The following is quoted from the Bulletin of the U. S. Department of Agriculture on Foods and Food Adulterations. "The examination of the coffees and coffee preparations on our markets show that the consumer, and especially the poor, are being grossly deceived. Very little pure ground coffee is sold, and even whole coffee does not escape sophistication. The purchase of green coffee for home roasting does not insure a pure product, since green coffee is imitated. Stringent laws are certainly needed to repress these frauds."

TEA.

The tea plant is a hardy, evergreen shrub, and "tea" is its prepared leaf. The plant is cultivated chiefly in Asia; China provides about 51 % of our tea, Japan 42 %, India 7 %. Black tea and green tea are leaves of the same kind of plant, the character of tea produced depending on the manner in which the leaf is cured. For black tea, the leaves are bruised to liberate the juices, allowed to ferment, and then dried; for green tea, the fresh leaves are steamed, next rolled, and dried as quickly as possible in order to prevent fermentation. The exact details of the preparation of the two kinds of tea vary from farm to farm, and country to country, but the main difference in treatment is as stated above; black tea has been fermented, green tea has not.

Tea is astringent and gently excitant, and, in its finer varieties exerts a decided influence over the nervous system, evinced by the feeling of comfort and even exhilaration which it produces, and the unnatural wakefulness to which it gives rise, when taken in unusual quantities, or by those unaccustomed to its use. * *

* * Taken moderately, and by healthy individuals, it may be considered as perfectly harmless; but long continued in excessive quantity it is capable of inducing unpleasant nervous and dyspeptic symptoms, the necessary consequences of over-excitement of the brain and stomach.*

The most prominent characteristics of tea are very probably due to the presence of a substance called caffeine in it. A comparison of the properties of tea and coffee, shows that a decided similarity exists between them. The resemblance is easily explained if we recall that caffeine is found in coffee also. Tea contains no caffeo-tonnic acid; the essential oil which gives tea its aroma and

*U. S. Dispensatory.

flavor is quite different from the essential oil in coffee. The percentage of caffeine in tea varies from 1.0 % to 3.4 % (compare coffee); of essential oil, 0.6 % to 1.0 %. The market value of a tea is determined solely by the properties of the infusion it gives, and not by its chemical composition. The professional tea taster examines the quality of its flavor and the body of the infusion, and these factors determine the market value of a tea.

THE ADULTERATION OF TEA.

Here, as under coffee, there is no intention of giving a detailed description of methods of adulterations and their detection. The treatment will be brief, and only in outline.

Facing.—The facing of tea is analogous to the facing of coffee, but it is of much more common occurrence. The leaves are moistened with rice water, warmed, and the finely powdered color shaken on, the mixture being continuously stirred until a uniform tint is produced. The pigments used, alone or in mixture, include Prussian blue, indigo, black lead and turmeric. The amount of coloring matter in faced tea is usually very small although statements have been made that 1 to 3 per cent. has been found. There is no evidence that the coloring matter is injurious to the health, but faced tea, according to the definition of adulteration given, is clearly adulterated.

Detection. The procedure is the same as for faced coffee. The tea is shaken with cold water and the liquid decanted before the detached particles have time to subside. The insoluble matter is allowed to settle; it may be collected, dried, and weighed, when the weight will allow one to form an estimate of the amount of coloring matter present. To detect the different pigments, the sediment is examined chemically or microscopically (see coffee.)

Exhausted Leaves.—The collection of exhausted tea leaves from restaurants, tea shops, etc., forms quite a business in some countries. The refused leaves are dried, given the required color by facing, and used as an adulterant. The admixture of exhausted leaves appears to be a most common and fraudulent practice, and one not easy to detect.

Detection. Since a portion of the tea leaf is dissolved by water, exhausted tea leaves contain a lower per cent. of soluble matter, and a higher per cent. of insoluble, than fresh leaves. The percentage of soluble or insoluble constituents forms a basis for an opinion as to the presence or absence of exhausted leaves. Total ash, insoluble ash, and insoluble leaf give the most reliable indications. By total ash is meant the per cent. of residue left on burning the tea; by insoluble ash, the portion of this residue insoluble in water. The difference is of course the ash soluble in water. Insoluble leaf is the percentage of insoluble matter left by treating the tea with successive portions of hot water until

all soluble matter is removed. The percentage of insoluble leaf is much higher in an exhausted tea than in a fresh tea, the per cent. of total ash lower unless the tea is faced. It would be an easy matter to determine if tea is composed entirely of exhausted leaves, but exhausted tea is used to mix, used as an adulterant, and in a mixture the problem is much more difficult. If pure tea were constant in composition the admixture of spent tea would be easily detected, but tea varies considerably in composition; the percentage of total ash, insoluble ash, insoluble leaf, vary greatly from sample to sample of tea known to be pure. The appearance of the leaves is a great aid in rendering a decision. If they are frayed, partly unrolled, or much broken, there is evidence of spent tea. When individual exhausted leaves can be separated, the results of an analysis would be conclusive. Standards have been adopted by many chemists to aid them in rendering a decision; thus, if the insoluble leaf is over 60 per cent., or the total ash is lower than 4.5 per cent., or the ash soluble in water less than 40 per cent. of the total ash, the tea is likely to be condemned. These standards have been formulated as the result of many analyses, and are intended to condemn no pure tea.

Foreign Leaves.—The Chinese occasionally employ ash, camelia, and dog rose leaves as tea adulterants, and leaves from the sloe, willow, beech, hawthorn, etc., have been used. Such leaves are at present a rare adulteration. Battershall states that foreign leaves were present in only a few samples of the 2,000 suspected teas examined under his direction for the purpose of enforcing the United States Tea Adulteration Act.

Detection. Leaves from different kinds of plants vary greatly in their shape, arrangement of veins, and in the minute details of their structure. The suspected leaves are soaked in hot water, carefully unrolled on a glass plate, and examined with a small lens. Those familiar with the tea leaf may usually identify even small fragments in this manner. In cases of doubt the microscope is used. The structure and arrangement of the cells which make up a tea leaf are so different from that of other leaves that the microscope will furnish conclusive evidence whether a leaf, or even the powder of a leaf, is from the tea or some other plant.

Astringents.—These are added to make a tea appear stronger than it really is. Catechu, a powerful astringent, sometimes used, is detected by boiling the tea infusion with an excess of litharge, and bringing the filtrate from this in contact with a dilute solution of ferric chloride. A green precipitate shows catechu. Iron salts, also used as astringents, are detected by the usual qualitative tests for iron in the solution obtained by the action of dilute acetic acid on the tea.

EXAMINATION OF SAMPLES BOUGHT ON THE OPEN MARKET.

DESCRIPTION OF SAMPLES.

Laboratory Number.	Name.	Price per Pound.	Where Purchased.
1065	Royal Pekin, mixed.....	.60	Statesville.
1066	Austin & Co., black.....	.40	Statesville.
1067	Austin & Co., black.....	.60	Statesville.
1068	Austin & Co., black.....	.80	Statesville.
1069	Austin & Co., green.....	.60	Statesville.
1071	He-No, mixed.....	.80	Raleigh.
1072	Deboy & Co., mixed.....	.40	Raleigh.
1073	Gunpowder, green.....	.60	Raleigh.
1074	Black tea.....	.40	Raleigh.

Facing.—The following samples were faced :

- 1065, facing contained black lead.
- 1067, facing contained black lead.
- 1069, facing contained Prussian blue.
- 1073, facing contained Prussian blue.

Of 9 teas, 4 or 44 % were faced.

Exhausted Leaves.—The determination of insoluble leaf, total and insoluble ash were made according to the methods given in Bulletin 13, Division of Chemistry, U. S. Department of Agriculture. The results are given in the table.

Number.	Insoluble Leaf.	Total Ash.	Soluble Ash.	Per Cent. Soluble Ash of Insoluble Ash.
1065	47.80	6.07	3.63	59.8
1066	59.15	6.06	3.04	59.2
1067	53.17	6.45	3.99	61.9
1068	49.96	6.37	4.05	63.6
1071	53.08	6.05	3.96	65.4
1072	53.38	5.98	3.60	60.2
1073	53.35	7.46	3.30	44.4
1074	53.09	6.87	3.89	56.6

There is no reason to suppose any of the teas are adulterated with spent tea leaves.

Foreign Leaves.—None found.

Astringents.—Iron, copper, and catechu were not present.

EFFECT OF LEGISLATION ON TEA ADULTERATION.

An act was passed by Congress in 1883, which prohibited the importation of any tea "adulterated with spurious leaf or with exhausted leaf, or which contains so great an admixture of chemicals or other deleterious substances as to make it unfit for use."

Dr. Battershall, who had charge of the chemical examination of the tea entered at New York city, states that the quality of the tea imported there has improved very perceptibly since the enforcement of the Adulteration Act.